PHYSICS

NCERT - NCERT PHYSICS(ENGLISH)

UNITS AND MEASUREMENT

Solved Example

1. Calculate the angle of (a) 1° (degree) (b) 1' (minute of arc of are min) and (c) 1''(secondof arc of arc sec) in radian. Use $360^\circ = 2\pi rad.$, $1^\circ = 60'$ and 1' = 60''.

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2. A man wishes to estimate the distance of a nearby tower from him. He stands at a point A in front of the tower C and spots a very distant object O in line with AC. He then walks perpendicualr to AC upto B, a distaance of 100m and looks at O and C again. Since O is very distant, the direction of BO is practically the same as AO, but he finds the line of sight of C shifted from the original line of sight by an angle $\theta = 40^{\circ}$ (θ is known as parallax). Estimate the distance fo the tower C from his original position A.

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3. The moon is observed from two diametrically opposite points A and B on earth. The angle θ substended at the moon by the two directions of observation is $1^{\circ}54'$. Given the diameter of earth to be about $1.276 \times 10^7 m,$ calculate the distance of moon from earth.

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4. The sun's angular diameter is measured to be 1920''. The distance of the sun from the earth is $1.496 \times 10^{11} m.$ What is the diameter of the sun?

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5. If the size of a nucleus $\left(\approx 10^{-15}m\right)$ is scaled up to the tip of a sharp pin $\left(\approx 10^{-5}m\right)$, what roughly is the size of an atom?

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6. Two clocks are being tested against a standard clock located in a national laboratory. At 12:00:00 noon by the standard clock, the readings of the two clocks are :

	Clock 1	Clock 2
Monday	12:00:05	10:15:06
Tuesday	12:01:15	10:14:59
Wednesday	11:59:08	10:15:18
Thursday	12:01:50	10:15:07
Friday	11:59:15	10:14:53
Saturday	12:01:30	10:15:24
Sunday	12:01:19	10:15:11

If you are doing an experiment that requires precision time interval measurements, which of the two clocks will you prefer ?

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7. In successive measurement, the reading of the period of oscillation of a simple pendulum were found to be 2.63s, 2.56s, 2.71s and 2.80s in an experiment. Calculate (i) mean value of the period oscillation (ii) absolute errer in each measurement (iii) mean absolute error (iv) releative error (v) percentage error and (vi) express the result in proper form.

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8. The temperature of two bodies measured by a thermometer are $(20 \pm 0.5)^{\circ} C$ and

$(50 \pm 0.5)^\circ C$. Calculate the temperature difference with error limits.

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9. The resistance $R = \frac{V}{I}$, where $V = (100 \pm 5.0)V$ and $I = (10 \pm 0.2)A$. Find the percentage error in R.

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10. Two resistors of resistances $R_1 = 100 \pm 3$ ohm and $R_2 = 200 \pm 4$ ohm are connected (a) in series, (b) in parallel. Find the equivalent resistance of the (a) series combination, (b) parallel combination. Use for (a) the relation $R = R_1 + R_2$ and for (b) $\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2}$ and $\frac{\Delta R'}{R}'^2 = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$

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11. Find the relative error in Z, if $Z = A^4 B^{1/3} / CD^{3/2}$ and the percentage error in the measurements of A,B,C and D are 4%,2%,3% and 1% respectively.

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12. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{L/g}$. Measured value of L is $20.0cm$ known to $1mm$ accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1 s resolution. What is the accuracy in the determination of g?

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13. Each side of a cube is measured to be 7.203 m . What is (i) the total surface area and (ii) the volume of the cube to appropriate significant figures ?

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14. A substance weight 5.74 g occupies a volume of $1.2cm^3$. Caluclate its density with due regard to significant digits.

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15. Let us consider an equaiton

$$\frac{1}{2}mv^2 = mgh,$$

Where m is the mass of the body, v its velocity, g is acceleration due to gravity and h is the height. Cheak whether this equation is dimensionally correct.

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16. The SI unit of energy is $J = kgm^2 s^{-2}$, that of speed v is ms^{-1} and of acceleration a is

ms^{-2} which of the formulae for kinetic energy (K) given below can you rule out on the basis of dimensional arguments (m stands for the mass of the body).

(a) $K = m^2 v^3$ (b) $K = \frac{1}{2} m v^2$ (c) K= ma

(d) $K = \frac{3}{16} m v^2$ (e) $K = \frac{1}{2} m v^2 + ma$

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17. Consider a simple pendulum having a bob attached to a string that oscillates under the action of a force of gravity. Suppose that the period of oscillation of the simple pendulum depends on its length (l), mass of the bob (m) and acc. due to gravity (g). Derive the expression for its time period using method of dimensions.

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Exercise

1. Fill in the blanks

(a) The volume of a cube of side 1 cm isk equal to..... m^3

(b) the surface area fo a solid cylinder of radius

2.0 cm and height 10.0 cm is equal to .... $(mm)^2$

(c) A vehical moving with a speed of $18 kmh^{-1}$

covers ....m in 1s.

(d) The relative density of lead is 11.3. its

density is ......g cm^{-3} or $\ldots\ldots kgm^{-3}$

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2. Fill in the blanks by suitable conversion of

units :

(a) $1kgm^2s^{-2} = gcm^2s^{-2}$ (b) 1m = ... Light year (c) $3ms^{-2} = \ldots\ldots Kmh^{-2}$

(d)

$G = 6.67 \times 10^{-11} Nm^2kg^{-2} = \ldots\ldots cm^3s^{-2}g^{-1}$

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3. A calorie is a unit of heat or energy and it equals about $4.2J, where 1J = 1kgm^2s^{-2}$. Suppose we employ a system of units in which the unit of mass equals αkg, the unit of length equals is βm , the unit of time is γs. Show tthat a calorie has a magnitude $4.2\alpha^{-1}\beta^{-1}\gamma^{2}$ in terms of the new units.

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4. Explain this statement clearly :

"To call a dimensional quantity 'large' or 'small' is meaningless without specifying a standard for comparison". In view of this, reframe the following statement wherever necessary :

(a) atoms are very small objects

(b) a jet plane moves with great speed

(c) the mass of Jupiter is very large

(d) the air inside this room contains a large number of molecules

(e) a proton is much more massive than an electron

(f) the speed of sound is much smaller than the speed of light.

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5. A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the sun and the earth in terms of the new unit, if light takes 8 min and 20 sec. to cover the distance ?

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6. Which of the following is the most precise device for measuring length

(i) a vernier calipers with 20 divisions on the sliding scale (ii) a screw gauge of pitch Imm and 100 divisions on the circular scale (iii) an optical instrument that can measure length to within a wavelength of light?

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7. A student measures the thickness of a human hair by looking at it through a microscope of magnification 100. He makes 20 observations and findsd that the average width of the hair in the field of view of the microscope is 3.5mm. What is his estimate on the thickness of hair?

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8. Answer the following :

(a) You are given a tread and a metre scale. How will you estimate the diameter of the thread ?

(b) A screw gauge has a pitch of 1.0 mm and 200 divisions on the circular scale. Do you think it is possible to increase the accuracy of the screw gauge arbitrarily by increasing the number of divisions on the circular scale ?

(c) The mean diameter of a thin brass rod is to be measured by vernier callipers. Why is a set of 100 measurements of the diameter expected to yield a more reliable estimate than a set of 5 measurement only ?

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9. The photograph of a house occupies an area of $1.7cm^2$ on a 35 slide. The slide is projected on to a screen, and the area of the house on the screen is $1.55m^2$ What is the liner magnification of the projector screen arrangement?

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10. State the number of significant figures in the following : (a) $0.007m^2$ (b) $2.64 \times 10^{24} kg$ (c) $0.2370 gcm^{-3}$ (d) $6.320J$ (e) $6.032Nm^{-2}$ (f) $0.0006032m^2$

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11. The length , breadth , and thickness of a metal sheet are $4.234m, 1.005m,$ and $2.01cm$, respectively. Give the area and volume of the sheet to the correct number of significant figures.

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12. The mass of a box measured by a grocer's balance is 2.300kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is (a) the total mass of the box, (b) the difference in the masses of the pieces to correct significant figures?

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13. A physical quantity P is related to four observables a, b, c and d as $P = a^3 b^2 / \sqrt{c} d$. The percentage errors in the measurements of a, b, c and d are 1%, 3% 4% and 2% respectively. What is the percentage error in the quantity P?

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14. A book with many printing errors contains four different forumlae for the displacement y of a particle undergoing a certain periodic motion : (i) $y = a\frac{\sin(2\pi t)}{T}$ (ii) $y = a \sin vt$ (iii) $y = \frac{a}{T}\frac{\sin(t)}{a}$ (iv) $y = \frac{a}{\sqrt{2}}\left[\frac{\sin(2\pi t)}{T} + \frac{\cos(2\pi t)}{T}\right]$ Here, a is maximum displacement of particle, v is speed of particle, T is time period of motion. Rule out the wrong forumlae on dimensinal grounds.

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15. A famous relation in phyics relates the moving mass m to the rest mass m_0 of a particle in terms of its speed v and the speed of light c.(This relation first arose as a consequence of the special theory of relativity due to Albert Einstein). A boy recalls the relation almost correctly but forgets where to put the constant c . He writes $m = \frac{m_0}{(1 - V^2)^{1/2}}$. Guess where to put the missing c.

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16. The unit of length convenient on the atomic scales is known as an angstrom and is denoted by $\text{Å}: 1\text{Å} = 10^{-10}m$. The size of a hydrogen atom is about 0.5Å What is the total atomic volume in m^3 of a mole of hydrogen atoms?

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17. One mole of an ideal gas at NTP occupies 22.4 liters (molar volume). What is the ratio of molar volume to atomic volume to atomic volume of a mole of hydrogen ? Take size of hydrogen molecule to be 1 Å. Why is this ratio so large?

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18. Explain this common observation clearly : If you look out of the window of a fast moving train, the nearby tress, houses etc. seem to move rapidly in a direction opposite to the train's motion, but the distant objects (hill tops, the Moon, the starts etc.) seem to be stationary. (In fact, since you are aware that you are moving, these distant objects seem to move with you).

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19. The principle of 'parallax' in Art. 1(c).4. is used in the determination of distacne of very distant stars. The baseline AB in the line joining the Earth's two locations six months apart in its orbit around the sun. That is, the baseline is about the diameter of the Earth 's orbit $\approx 3 \times 10^{11} m.$ However, even the nearest stars are so distnat thet with such a long baseline, they show parallax only of the order of 1''(second) of arc or so . A parsec is a convenient unit of length on the astronomical scale. It is the distance of an objhect that will shown a parallax of 1'' (second) of arc fome oppsoite ends of a beasline equal to the distance from the Earth to the sun. How much is a parsec in terms of metres ?

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20. The nearest star to our solar system is 4.29 light years away. How mcuh is this distance in terms of par sec ? How mcuh parallax would this star show when viewed from two locations of the earth six months apart in its orbit around the sun?

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21. Precise measurements of physical quantities are a need of science. For example to ascertain the speed of an aircraft, one must have an accurate method to find its positions at closely separated instants of time. This was the actual motivation behind the discovery of radar in World War II. think of different examples in modern science where precise measurements of length, time, mass etc, arc needed. Also, where ever you can, give a quantitative idea of the precision needed.

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22. Just as precise measurements are necessary in science, it is equally important to be able to make rough estimates of quantities using rudimentary ideas and common observations. Think of ways by which you can estimate the following (where an estimate is difficult to obtain. try to get upper bound on the quantity) :

(a) the total mass of rain-bearing clouds over India during the Monsoon

(b) the mass of an elephant

(c) the wind speed during a storm

(d) the number of strands of hair on your head

(e) the number of air molecules in your classroom.

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23. The sun is a hot plasma (ionised matter) with its linner core at a temperature excedding 10^7 K, and its outer surface at a temperature of about 6000K. At such high temps, no substance remains in a solid or liquid phase. In what range do you expect the mass density of the sun to be? In the range of densities of solids, liquieds or gases ? Check if your guess is correct from the following data : mass of sun $= 2.0 \times 10^{30} kg$, radius of the sun $= 7.0 \times 10^{8} m$

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24. When planet Jupiter is at a distance of 824.7 million km from earth, its angular diameter is measured to be 35.72'' of arc. Calculate the diameter of Jupiter.

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25. A man wlaking briskly in rain with speed v must slant his umbrella forward making an angle θ with the vertical . A student derives the following relation between θ and v :

tan $\theta = v$

and checks that the relations has a correct limit : as $v \to 0, \theta \to 0$, as expected . (We are assuming there is no string wing and that the rains falls vertically for a stationary man). Do you think this relation can be correct ? If not, guess at the correct relation .

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26. It is claimed that two atomic clocks if allowed to run for 100 years, free from any disturbance, may differ by only about 0.02 second. In measuring a time interval of second what is the accuracy?

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27. Estimate the average atomic mass density of a sodium atom, assuming its size to be 2.5 Å. Compare it with density of sodium in its crystalline phase $(970 kg m^{-3})$. Are the two densities of the same order of magnitude ? If so, why ?

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28. The unit of length convenient on nuclear scale is a fermi, $(1 f = 10^{-15})$m. Nuclear sizes obey roughly the following empirical relation :

$r = r_0 A^{1/3}$, where r is radius of the nucleus and r_0 is a constant equal to 1.2 f. show that the rule implies that nuclear mass density in nearly constant for different nuclei. Estimate the mass density of sodium nucleus. Compare it with average mass density of sodium atom is Q. 27 $(4.67 \times 10^3 kg/m^3)$.

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29. A LASER is source of very intense, monochromatic, and unidirectional beam of light. These properties of a laser light can be exploited to measure long distance. The distance of the moon from the Earth has been already determine very precisly at the moon's surface. How much is the radius of the lunar orbit around the Earth?

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30. A SONAR (sound navigation and ranging) uses ultrasonic waves to detect and locate object under water. In a submarine equaipped with as SONAR, the time delay between genration of a probe wave and the recption of its echo after refection from an enemy submarine is found to be 77.0 s. What is the distance of the enemy submarine ? (speed of sound in water $= 1450 ms^{-1}$

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31. The farthest objects in out universe discovered by modern astronomeres are so distant that light emitted by them takes billions of year to reach the earth. These object (known as quasers) have may puzzling features, which have yet not been satisfactorily explained. What is the distance in km of a quasar form which light takes 3.0 billion years to reach us?

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32. It is a well known fact that during a total solar eclipes the disc of the moon almost completely covers the disc of the sun. From this fact and from the information you can gather from Solved Examples 3 and 4 on page 1//44, determine the approximate diameter of the moon.

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33. A great physicist of this century (P. A. M. Dirac) loved playing with numerical values of fundamental constant of nature. This led him to an instreasing observaion. Dirac found that form the basic constant of atomin physice (c,e, mass of electron mass of proton) and the gravitational constant G, he could arrive at a number with the dimension of time. Further, it was a very large number, its magnitude being close to the present estimate on the age of the universe ($\approx 15 billion years$). Form the table of fundamental constants in this book, try to see if you too can construct this number (or any other instresting number you can think of). if its coincidence with the age of the universe ware significant, what would this imply for the constancy of fundamental constants ?

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